

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of:

Larry C. Olsen et al.

Application No. 10/726,744

Filed: December 2, 2003

Confirmation No. 6833

For: THERMOELECTRIC DEVICES AND
APPLICATIONS FOR THE SAME

Examiner: Jeffrey Thomas Barton

Art Unit: 1795

Attorney Reference No. 23-65037-01

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DECLARATION UNDER 37 CFR § 1.132

JOHN G. DESTEESE, being duly sworn does hereby declare and affirm the following:

That he received a Bachelor of Science degree in Electrical Engineering from the University of London in 1960; that he has over 48 years' experience in analysis and development of power delivery systems that extract, convert, transport or store energy.

That he is a co-inventor of the invention claimed in Application No. 10/726,744 and that he is employed by Battelle Memorial Institute, the Assignee of Application No. 10/726,744.

That he was employed as a Senior Development Engineer in the aerospace industry at both TRW, Incorporated from 1964 to 1966 and McDonnell Douglas Corporation from 1966 to 1973; that he previously worked as a Research Engineer in the electric power industry at Westinghouse Electric Corporation, from 1961 to 1964; that he contributed to the development of thermoelectric generators and other direct energy conversion devices for each of these prior employers.

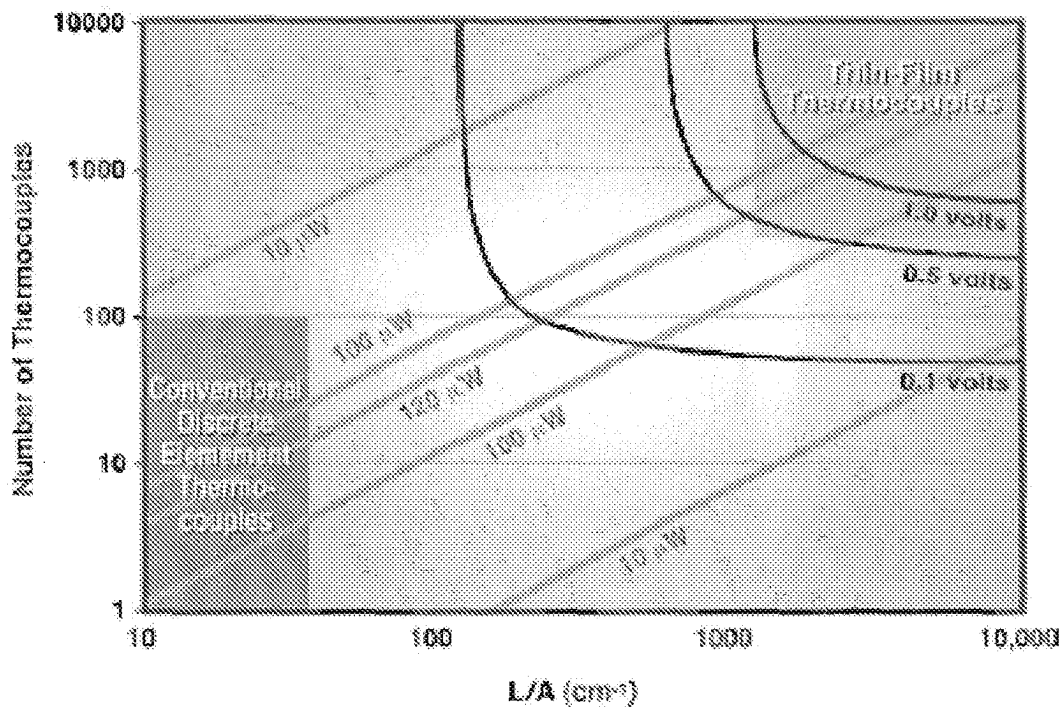
That he currently is a Staff Engineer and has been employed by Battelle Memorial Institute since 1973; that his professional experience covers a broad range and includes advanced energy conversion research and development; innovation and analysis of system concepts, and planning, integration and management of system development programs; that his research specialties currently include the capture of heat and other forms of ambient energy and their conversion into electrical power and that he continues to lead Battelle Memorial Institute research to further improve the developed thermoelectric power sources and methods.

That he has read the Examiner's rejections in regard to the pending claims in Application No. 10/726,744 in the Office action dated August 4, 2008, the Migowski and Buist references cited therein, and that he participated in the Examiner/Applicant Interview that took place on February 12, 2009, and discussed with the Examiner the criticality of the thermoelectric thermoelement thin film thicknesses and the leg length to area (L/A) ratios of the thermoelements of the disclosed and claimed thermoelectric power sources and methods.

That he actively participated in the conception, research and development of the thermoelectric power sources and methods as disclosed in this and related applications. That he actively participated in the analysis that identified preferred and critical design regimes based on thermoelement L/A ratios as summarized in the figure below, where output voltage contours and power are shown on a chart of thermocouple number versus L/A ratios.

That, for a given difference in source and sink temperature, L/A ratios define preferred design boundaries and are critical to achieving the required performance of thin-film, multi-element thermoelectric generators. That high L/A ratios are generally critical to achieve the Applicants' device desired output voltage; that the width of the deposited thermoelectric film and the film thickness determine the area of each thermoelement and are, in turn, important design parameters that control the internal resistance, output voltage and power of an multi-element assembly. That each plot of this type as based on temperature difference and intrinsic material properties will define a preferred and critical design region in which L/A of thin-film deposits is much higher than can be achieved with discrete, self-supporting thermoelements. It should be noted, for given conditions, yet higher L/A ratios produce lower power devices because

implicitly higher internal resistance of the TE generator limits output. For example, the 11-microwatt thermogenerator for a watch disclosed by Migowski has thermoelements with an L/A of $15,000 \text{ cm}^{-1}$ which is off scale beyond the upper range of the figure. That an L/A ratio as high as Migowski discloses limits output to between 10 and 20 microwatts in the configuration of his device and the environment in which it is designed to operate.



That the L/A ratio is a critical aspect in the design of the disclosed and claimed thermoelectric power source that includes multiple p-type and n-type thermoelements. That through his research and analysis he discovered that an L/A ratio greater than several hundred (500 cm^{-1} for example) is critical for Applicants' preferred low-power applications – to which power applications the disclosed thermoelectric devices and methods are aimed. That L/A ratios were carefully optimized to achieve a useful voltage directly without need for further amplification and an electrical impedance match with the electrical circuit of the application (e.g., a sensor and/or transmitter) in a relatively small power source device. That the superior results in the developed thermoelectric devices as claimed so that the thermoelectric generator

may be treated similar to a "plug-in" battery with a comparable voltage, thereby eliminating the need for voltage amplification components and their inherent power consumption.

That the following table illustrates a comparison of the present invention with the Migowski disclosure. That for the purposes of comparison the temperature difference is made the same although Applicants' device is designed to produce about 510 microwatts with about a 20°C-temperature difference.

Device Parameters	Embodiment of Applicants' Disclosed Device	Migowski Disclosure
Thermoelement width (cm)	0.4	0.01
Thermoelement L/A (cm ⁻¹)	781	15,000
Temperature difference (°C)	6	6
Output voltage (V)	3.0	1.6
Power (μW)	153	11

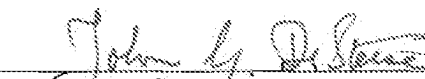
That the table above illustrates that optimizing L/A ratios in consideration of material properties and other design requirements produces Applicants' disclosed device with over ten times the output of the Migowski disclosed device when exposed to similar environmental conditions.

That the thicknesses of the thermoelements as recited in the presently claimed device are likewise critical to the operation of the device as the thermoelement thicknesses, along with other parameters of the thermoelements, determine the ultimate TE power source output. That thicker deposits allow the design of higher power output devices than are possible with prior art devices, while maintaining desired L/A ratios such that the thermoelectric, impedance and thermal properties of the device are also optimized for the ultimate application of the TE power source device. That such optimization includes depositing p-type materials with different widths to those of n-type materials providing each with a different L/A to compensate differences in their electrical conductivity. That Migowski only discloses much thinner thermoelements (p. 4, layer

thickness of 0.005 mm) and asserts that the layers be as thin as possible. Buist does not disclose a layer thickness at all — completely failing to recognize the importance of this parameter.

The undersigned declares that all statements made herein of his knowledge are true and that all statements made on information and belief are believed to be true and further, that these statements were made with the knowledge that willful false statements and the like are punishable by fine or imprisonment under Section 1001 of Title 18 of the United States Code, and that any such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

Executed at the place and date opposite the signature below.


John G. DeStees

At Richland, Washington
(City and State)
on this 7th day of April, 2009.